DOCUMENT

DE TRAVAIL

N° 333

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July 2011

BANQUE DE FRANCE

EUROSYSTÈME

DIRECTION GÉNÉRALE DES ÉTUDES ET DES RELATIONS INTERNATIONALES

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Macroeconomic consequences of global endogenous migration: a general equilibrium analysis*

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*This paper is based on research carried out in the EU 6th framework funded research project ENEPO, Project n° 028736 - 6e PCRD (FP6). We would like to thank Ahmed Tritah for his help on data processing. We are grateful to Juha Alho, Agnès Bénassy-Quéré, Martine Carré, Cécily Defoort, Frédéric Docquier, Luca Marchiori, Sandra Poncet, Christophe Trebesch, participants to the "migration and development" conference in Lille and two anonymous referees for useful comments and suggestions. An earlier version has been published as a CEPII working paper. This paper reflects the opinions of the authors and does not necessarily express the views of the institutions they are affiliated with. The usual disclaimers apply. Correspondence: xavier.chojnicki@univ-lille2.fr

Abstract

In this paper, we analyze the consequences of endogenous migration flows over the coming decades in a dynamic general equilibrium model of the world economy. Such an approach has two major benefits. First, it offers a global perspective on the economic consequences of international migration flows by taking into account effects on both the destination and the origin regions. Second, by allowing migration flows to be related to economic fundamentals, they are determined endogenously in the model. We proceed by estimating the determinants of migration in an econometric model and then endogenizing migration flows by introducing the estimated relationships between demographic and income developments in our world model. We show that (i) migration could have a substantial impact on GDP growth in sending and destination regions; (ii) endogenizing migration induces important changes in the volume and the distribution of migration flows between regions compared to the United-Nations projections; (iii) the size of these flows, although substantial, will not be sufficient to counteract the impact of population ageing in the receiving regions.

J.E.L. classification number: F21, C68, J61, H55.

Keywords: CGEM, Migration, International capital flows

Résumé

Dans cet article, nous analysons les conséquences démographiques et économiques de flux migratoires endogènes lors des prochaines décennies à l'aide d'un modèle multi-régions en équilibre général calculable à générations imbriquées (INGENUE2) dans lequel le monde est divisé en 10 régions. Notre analyse permet d'offrir une perspective globale des conséquences des migrations internationales. En effet, la particularité du modèle INGENUE2 est de pouvoir étudier simultanément des conséquences des migrations internationales à la fois du point de vue des pays d'origine et des pays d'accueil. Une autre innovation de cet article est de traiter les migrations internationales de manière endogène. Dans une première étape, nous estimons les déterminants des migrations en nous appuyant sur l'analyse économétrique. En particulier, nous montrons que le différentiel de revenu par tête constitue l'une des variables clés dans l'explication des flux migratoires. Dans une seconde étape, nous endogénéisons les flux migratoires dans le modèle INGENUE2. Pour ce faire, nous utilisons les relations estimées économétriquement entre les variables démographiques et économiques dans le cadre du modèle INGENUE2, ce qui nous permet de projeter les flux migratoires sur le long terme d'une façon plus fine que ne peuvent le faire les méthodes traditionnelle découlant des modèles purement démographiques.

Codes JEL : F21, C68, J61, H55.

Keywords: MEGC, Migration, Flux internationaux de capitaux flows

1 Introduction

In the XXIst century, the world economy is facing three major challenges. First, the demographic transition and the associated population ageing are putting the pay-as-you-go (PAYG) pension systems of OECD countries under pressure and are leading to various reforms. Second, the world economy is becoming increasingly interdependent. The deepening of the globalization process is reflected in increased levels of international trade, financial integration and international labour mobility. Third, the deepening globalization process may lead to changes in the world income distribution and, in particular, to an increase in North-South income inequalities. In the context of these three phenomena, we use an applied international general equilibrium model to study the long-term macroeconomic and demographic prospects of the world economy when international migration flows and economic developments are interdependent.

With rising life expectancies and declining fertility rates, the world has experienced since the beginning of the XXth century a major demographic transition which is affecting deeply the structure of its population. The world population is aging and the demographic transition will continue throughout the XXIst century. But the long global aging process which characterizes the transition path masks considerable variations across regions and countries. In particular, populations in OECD countries have been aging for some time now, and are thus in advance in the demographic transition compared to developing countries.

From an economic perspective, the fact that leading OECD countries have a declining labor force while they concentrate the largest part of the world capital stock suggests two adjustment mechanisms: capital moves to where workers are, or workers move to where the capital is. An abundant capital stock (relative to the labor force) in OECD countries means, all other things being equal, a low return on capital and therefore strong incentives to export capital towards regions with a small capital stock and an abundant labor force. The "triangular" relationship between population aging, pension reform, and international capital markets receives increasing attention in the academic literature(Börsch-Supan, Ludwig & Winter (2006), Aglietta et al. (2007) and Krueger & Ludwig (2007)). In this literature PAYG pension systems in OECD countries, along with asynchronous aging processes (and technological convergence), are strong predictors of international capital flows. Indeed, considering the growing number of elderly people compared to the working-age population in OECD countries, one can expect an increase of the pension contribution rates in these countries, with a strong impact on savings and capital markets.

A low labor force with an abundant capital also generates conditions for high earnings which attract workers from low earnings regions, i.e. from regions characterized by low capital-to-labor ratios. International capital flows and labor migration are then two strongly interdependent phenomena which should be analyzed simultaneously in an integrated framework. Our multi-regions general equilibrium setting also allows us to analyze the consequences of endogenous migrations, i.e. to take into account all the general equilibrium effects induced by such flows. More precisely, this approach allows us to analyze capital accumulation and international capital flows induced by the several dimensions of population dynamics (asynchronous ageing processes across regions coupled with endogenous migrations). Only few works deal with this question using an applied multi-country general equilibrium approach. Storesletten (2000) and Chojnicki, Docquier & Ragot (2005) study the impact of immigration in closed economy frameworks. Focusing on the skill differences between immigrants and natives, they show that the United States and France should benefit from inflows of high-skilled workers, which should moderate their fiscal burden. Chojnicki, Docquier & Ragot (2009) use a similar closed-economy framework and examine the economic impact of the second great immigration wave (1945-2000) on the US economy. In Fehr, Jokisch & Kotlikoff (2003, 2004), a three-country model (US, Europe and Japan) is considered to study the macroeconomic effects of doubling immigration on these countries. They show that growth in these countries is enhanced. But in such a framework, the impact of migration on sending countries and on inter-country inequalities cannot be dealt with. Moreover, as suggested by Fehr, Jokisch & Kotlikoff (2003), it seems necessary to take into account countries such as China and India in order to obtain realistic international capital flows for the coming decades.

In this paper, we offer a global perspective on the economic consequences of international migration. Indeed, the value-added of our model is that it is able to analyze the effects of international migration on both the destination and the origin regions. A further innovation of our world general equilibrium OLG model is that international migration is treated as endogenous[1]. In fact, migration flows are driven by several political, demographic and economic factors, that need to be carefully evaluated to assess migration potential at the world level. Here, we allow international migration to be related to some endogenous variables of our world model such as the GDP per capita differential, the demographic structure in the origin countries, poverty in the origin countries and the stock of migrants in the destination countries.

More precisely, our model describes a multi-region, world model in the spirit of those developed by Obstfeld & Rogoff (1996). The structure of each regional economy is an applied overlapping generations (OLG) general equilibrium model closely related to the seminal work of Auerbach & Kotlikoff (1987) except that labor supply is exogenous. The world is divided into ten regions according to geographical and demographic criteria. To endogenize international migration, we develop a two-step strategy. In a first step, we draw on the literature on the determinants of international migration (Clark, Hatton & Williamson (2007), Mayda (2007), Zaiceva (2006)) to estimate the determinants of international migration. In a second step, we introduce the estimated elasticities and model the interdependence between these determinants and international migration flows explicitly. With this interaction between the demographic part and the economic part of our world OLG model , we are able to project dynamic endogenous migration flows. Compared to the United-Nations (2006) projections, our methodology induces important changes in the volume and the distribution of migration flows between regions. For example, net migration flows from Africa are almost four times higher compared to the United-Nations (2006) projections in 2050. Nevertheless, one must note that this migration scenario, even if it induces a sharp increase in migration flows, does not totally offset the effect of ageing in the regions receiving the migrants: in this regard, pension reforms appear to be necessary in order to deal with the ageing problem that these regions will face in the near future. Concerning the regions sending the migrants, the adverse con-

[1] Docquier, Marchiori & Shen (2009) also develop such a unified framework to evaluate the global effects of brain drain on developing economies. However, this model does not treat international migration as endogenous.

sequences of emigration are more important the more the region is advanced in the ageing process and therefore already suffering from a declining population.

The rest of the paper is organized as follows. The macroeconomic model is presented in Section 2. Demographic assumptions and the introduction of migration flows follow in Section 3. Section 4 endogenizes migration flows in the context of our world model and section 5 describes the demographic and macroeconomic results. The sensitivity of endogenous migration projection is tested in section 6. Finally, Section 7 concludes.

2 INGENUE 2: A long-term model for the world economy

There are several reasons to adopt an open economy approach when addressing multi-country issues. First, the world economy is becoming increasingly interdependent. The deepening of the globalization process is reflected in increased levels of international trade, financial integration and international labor mobility that may lead to changes in the world income distribution and, in particular, in North-South income inequalities. Second, current population structures and demographic projections for the various regions of the world show that the ageing processes are not synchronous. This difference in time profiles of demographic changes suggests that one mechanism through which the pressure on pension systems could be eased is inter-temporal trade in the form of international capital flows. Third, along with international capital flows, international migration is a key feature in the process of income convergence between countries. Hence, international macroeconomic models are required to accurately assess the cost and benefits of such policies.

Our economic simulations are performed with the computable, general equilibrium, multi-regional OLG model INGENUE 2[2]. The World is divided into 10 regions according mainly to geographical and demographic criteria: Western Europe, Eastern Europe, North America, Latin America, Japan, Mediterranean World, Chinese World, Africa, Russian World and Indian World. Each of the ten regions consists of three categories of economic agents: households, firms and a PAYG retirement pension system. Furthermore, we assume the existence of a fictive producer of a world intermediate good.

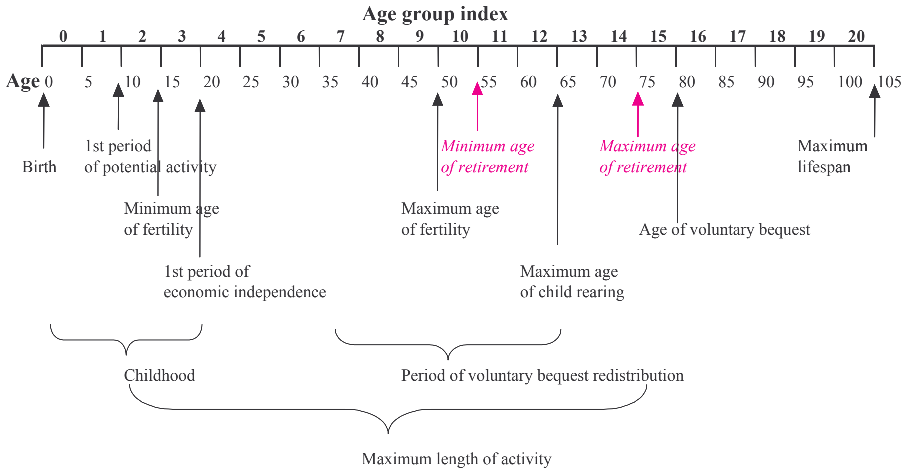
2.1 Household behavior

The period of the model is set to five years. In each region, the economy is populated by 21 overlapping generations who live up to a maximum age of 105. The individual life-cycle of a representative agent is described in Figure 1. Between ages 0 and 19, agents are children and are supported by their parents. Given the specificities of developing countries, we assume that children can begin to work at age 10 but their income is included in their parents' income. At age 20, agents become independent

[2]The INGENUE 2 model was developed at CEPII, CEPREMAP and OFCE. For technical features of the INGENUE 2 model, as well as the baseline scenario and a sensitivity analysis of the main structural parameters, see Ingenue (2006, 2007).

and start working. When becoming independent, individuals make economic decisions according to the life cycle hypothesis. A voluntary bequest is left to children at age 80 conditional on survival until 80.

Figure 1: The individual life cycle



In the budget constraint, the expenditures consist of consumption (including costs of children) and saving in each age and each period. On the income side there is, first, the return on accumulated savings corrected by one-period survival probabilities. Second, there is non-financial income that depends on age: labor income (after social security taxes) adjusted by a region-specific age profile of labor force participation for people in full labor activity; a mix of labor income and pension benefits for people partially retired (reduced labor activity); full pension benefits for people entirely retired. The lifetime utility is maximized under the intertemporal budget constraint, taking prices, social contributions and benefits as given.

2.2 The public sector

The public sector is reduced to a social security department. It is a PAYG public pension scheme, that is supposed to exist in all regions of the world. It is financed by a payroll tax on all labor incomes and pays pensions to retired households. The regional PAYG systems operate according to a defined-benefit rule. The exogenous parameters are the retirement age and the replacement ratio (Table 1). They are region-specific and fixed to their 2000 value through the entire projection period. Regional contribution rates are determined so as to balance the budget, period by period. For example, in Western Europe, keeping the replacement rate constant induced a marked increase in the contribution rate from 17.1% in 2000 to 31.9% in 2050 (Table 6). Conversely, maintaining the European pension contribution rate constant induces a progressive and significant decline of the replacement rate by 55% in 2050 (see Ingenue (2005) for more details).

Table 1: Replacement ratio in 2000

N. America	**W. Europe**	**Japan**	**S. America**	**Mediterranean**
37%	48%	45%	66%	39%
Africa	**Russia**	**China**	**India**	**E. Europe**
14%	35%	24%	43%	51%

Source: Authors calculations

2.3 The production side and the world capital market

We assume that the different regions produce different imperfectly substitutable intermediate goods using labor and capital. In the spirit of Backus, Kehoe & Kydland (1995), we assume that the domestic composite final good of each region is produced according to a combination of the domestic intermediate good and an homogenous world good imported by the region from a world market. In order to simplify the exchanges of intermediate goods between regions, this homogenous world good is "produced" by a fictive world producer as the output of a combination of all intermediate goods exported by the regions.

In each type of sector, firms act on competitive markets. They maximize their profit under their production constraint, taking prices as given. In the domestic intermediate good sector, the constraint is intertemporal since the production function depends on the stock of capital which is depreciated and accumulated. Intermediate goods producers thus maximize net present value of future cash flows, i.e. production values minus wage cost and capital cost. The latter depends on the depreciation rate which is itself affected by international capital market imperfection.

More precisely, the depreciation rate is asymmetrically dependent on the ownership ratio, defined as the ratio of the total wealth of households to the capital stock. Indeed, firms located in countries that are indebted to the rest of the world borrow at a higher interest rate than the world interest rate and this "indebtedness premium" is proportional to its financial market exposure (measured by the ownership ratio). At equilibrium, the marginal return of capital thus depends on the net external position. In net debtor regions (ownership ratio less than one), the imperfection of international financial markets raises the cost of capital. It shows up in a higher rate of depreciation of the capital stock which in turns reduces the incentive to produce the intermediate good. In net creditor regions (ownership ratio above one), the rate of depreciation is a constant, thus independent from the financial position.

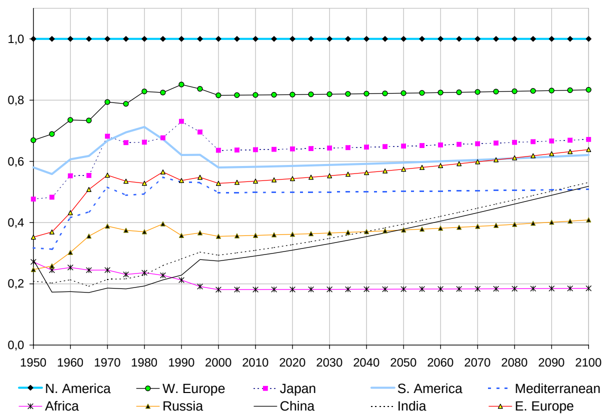
2.4 Technological catch-up

The basic trends that shape the future growth regime are the demographic transition and the diffusion of technological progress. These factors have always been prevalent in the rise of capitalism worldwide and they explain the current and future trends in terms of convergence (or divergence) in real income per capita between countries.

All production functions are augmented by Total Factor Productivity (TFP) at constant prices which is a synthetic measure of technological progress for the whole economy. For 1950 until 2000, the growth rate of TFP is given by historical data (Heston, Summers & Aten (2002)). After this date, the TFP growth rate is the result of a given, exogenous growth of 1.1% per annum in the North American region, supposed to be the technological leader, and a region-specific exogenous, catch-up factor, reflecting international diffusion of technological progress.

Figure 2 shows the profile of TFP in the ten regions of the INGENUE 2 model. Western Europe and Japan are assumed to resume their catch-up, meaning that they absorb the IT revolution after North America. Three regions have a sustained catch-up process: the takeoff in the Chinese world and the Indian world, which started in the 1990's is assumed to gain momentum. Eastern Europe is also assumed to be a fast-growing region due to its participation to the European Union. We adopt a dimmer view of the other regions. A relatively slow catching up is assumed in South America and in the Mediterranean countries where there are perennial difficulties in establishing efficient market institutions, in promoting a large class of entrepreneurs and in generating non-corrupt and competent governments. The same arises more seriously in Russia where the catastrophic decline of the population is a further handicap. Finally, we are more pessimistic about Africa where we assume no catch-up in the level of TFP. The impact of an alternative scenario of catching-up on migration is presented in section 6.

Figure 2: Total Factor Productivity: 1950-2100 (% of North American level)



sources: Heston et al. (2002), authors' calculation

2.5 Solving the model

The competitive world equilibrium stems from five set of equations: intertemporal utility maximization of households; intertemporal profit maximization of firms in intermediate goods sectors; period profit maximization of firms in final goods sectors; period profit maximization of the world producer; and market clearing conditions. The markets for intermediate goods, final goods, labor in each region, and the market for the world intermediate good, are cleared in each period. These equations determine all relative equilibrium prices expressed in a common numeraire, which is the price of the intermediate good in North America. This convention allows us to express values in constant dollars. Finally, Walras' law implies that the world financial market equilibrium is the redundant equation.

3 Introducing migration

3.1 Population projection method

Population evolution is calculated according to a standard population projection method on the basis of historical and prospective UN data. In the baseline scenario, we implicitly assume that there are no migration flows in the future. Our baseline population projection thus corresponds to the UN variant with no migration flows[3]. Then, we build a comprehensive migration scenario to analyze the demographic and economic consequences of international migration.

For that purpose, an immigration shock is introduced into the model as an increase in the number of young adults (aged between 20 and 24). After crossing the border, immigrants automatically become natives in an economic sense, i.e. they have the same preferences and fertility behavior as natives and adjust to the productivity and activity rates of the host region (Fehr et al. (2003, 2004) have the same assumption). Many studies show that immigration contributes very little to the global fertility rates of the host countries (See for example Camarota (2005) and Héran & Pison (2005)) so that the assumption of perfect fertility assimilation appears acceptable from a macroeconomic point of view. We test the sensitivity of our results to this assumption in section 6.

In particular, as in Storesletten (2000), we assume that immigrants move into receiving countries without any capital (note that natives have no wealth at the same age).[4] However, this choice seems to play a minor part for the results since most immigrants actually move before the age of 30, i.e. at the beginning of the wealth accumulation process[5].

After 2050, the demographic model is calibrated in order for the population to converge towards a stationary level. Between 2050 and 2100, we keep emigration rates constant at their 2050 values so that migration flows only evolve with the number of young workers in the emigration area. After 2100, migration flows progressively diminish and are nil in 2150.

3.2 Calibration of migration flows compatible with UN projections

International migrants are unevenly distributed across world regions. By 2005, 47% of the stock of international migrants were resident in industrial countries and 53% in developing countries[6]. The United-States, Canada and Australia (these 3 countries are regrouped in the North America region in the INGENUE 2 framework) are the major traditional destination countries of migration. Over one quarter of immigrants live in one of these 3 countries. Western Europe has experienced net inflows of migrants for four decades and represents the second major immigration area with 21% of the total immigrant stock. Eastern Europe and the former Soviet Union had

[3] See Ingenue (2007) for a complete description of the baseline.

[4] All these assumptions are necessary to avoid problems of agent heterogeneity that would complicate the computation of the transitory path.

[5] The median age of new immigrants is on average about 30 years in OECD countries and 27.7 in EU15 for non-EU immigrants

[6] Trends in Total Migrant Stock: The 2005 Revision, http://esa.un.org/migration

around 15% of the total immigrant stock in 2005. Finally, other regions are broadly characterized by a predominant labor migration through developed countries.

Following these facts and given data availability, our model essentially relies on migration flows toward the traditional countries of immigration. Thus, we distinguish three types of regions in the model:[7]

- pure immigration zones only face inward flows: Western Europe and North America;
- pure emigration zones only face outward flows: Latin America, Mediterranean World, Chinese World, Africa and Indian World;
- intermediate zones face simultaneously in- and outflows: Eastern Europe and Russian World.

We then adopt a calibration process that allows us to make actual net migration flows compatible with our multi-region description of the world using different data sources. First, we aggregate net migration flows by countries used in the medium variant of the United-Nations (2006) population projections to correspond to the INGENUE2 regional grouping. Then, we calibrate immigration flows to Western Europe, North America, Eastern Europe and the Russian World on UN figures removing intra-regional flows (for example German migration to France) as well as non pertinent flows for our analysis (for instance Western Europe migration to North America). Given the world aspect of our model, immigration in host regions has to correspond to emigration in sending regions. Thus, we have to allocate immigration flows by origin regions. For that purpose, we use the emigration stocks of 195 origin countries built by Docquier & Marfouk (2005) to allocate the immigration flows to Western Europe and North America.

However, Docquier & Marfouk (2005)'s database only focuses on OECD countries as receiving countries and there is no information on migration flows to Eastern Europe and the Russian world. Thus, for the two intermediate regions, we complete the information with the World Bank (2006) report on Eastern Europe and the former Soviet Union as well as with the data of Salt (2005). Table 2 gives the calibrated net migration flows by regions in 2005. Note that these flows appear lower than the UN official net flows given that we exclude intra-regional flows as well as many flows between developing countries. These flows thus represent almost 43% of the total net flows following from the United-Nations (2006) study and correspond to the greater part of migration through OECD countries.

Then, we reproduce this methodology for each five-year period in the future to match the UN projections with migration until 2050. This scenario is thus close to the United-Nations migration projection, which assumes that migration streams observed in the past decades are durable and thus relatively predictable. Table 4 gives the dynamics of net migration flows until 2050. Our first concern being the endogenous migration flows, we present the macroeconomic consequences of this exogenous conventional migration flows in appendix 3. Note that the results of this scenario are qualitatively similar to the ones of the endogenous scenario presented thereafter.

[7] Given the weakness of official figures, we assume that Japan is isolated to international mobility of workers.

Table 2: Yearly net migration flows by origin and destination countries in 2005 (in thousand)

	Destination Countries				
Origin Countries	Western Europe	North America	Eastern Europe	Russian World	Total Emigration
Mediterranean World	256.8	86.1	0.9	53.2	397.0
Indian World	*58.5*	*107.0*	*0.3*	*54.6*	220.5
Chinese World	*41.7*	*316.7*	*1.2*	*0.0*	359.6
Eastern Europe	53.0	21.6	-	0.0	74.5
Russian World	36.7	46.5	21.9	-	105.0
Latin America	51.8	649.3	0.1	0.0	701.3
Africa	125.3	69.8	0.1	0.0	195.3
Total Immigration	623.8	1297.1	24.6	107.8	2053.3

Sources : Docquier and Marfouk (2005), Salt (2005), United-Nations (2006), World Bank (2006); Authors' calculations

4 Endogenizing migration

Unlike fertility and mortality, which are in transition worldwide from high to low levels in a long historical process, there is much more uncertainty concerning net migration (see National Research Council (2000), Alho & Borgy (2008)). Therefore, migration projections have no strong and consistent trend that can serve as the backbone of credible projection assumptions for the future. For this reason, it is important to assess migration potential of these regions by analyzing the main driving forces of the past and recent trends.

However, migration is usually treated as a residual factor in demographic projections and migration projections rely more on informed judgments than on systematic modeling. For example, United-Nations (2006) projections estimate future migration by some arbitrary assumptions, such as constant flows in the future or flows declining toward zero, according to the country considered. This methodology is somewhat unsatisfactory and involves substantial errors on projected population, not so at the global level but on specific countries or regions.

Nevertheless, the basic motivations for migration are now well known even if there is no complete migration theory that accounts for all the relevant factors. The main driving forces of the past and recent trends in migration flows thus have to be fully analyzed so as to be integrated in a dynamic framework where the demography and the economy interact. To endogenize international migration, we develop a two-step strategy. In a first step, we estimate the determinants of migration flows on the basis of selected variables (Section 4.1). In a second step (Section 4.2), we relate demographic and macroeconomic dynamics between the regions through the econometric relation estimated in Section 4.1.

4.1 Estimation of the determinants of international migration

We first estimate the determinants of migration flows using an econometric model similar to Clark et al. (2007). For that purpose, we use data on international migration flows from the UN International Migration Flows to and from Selected Countries (IMSC) dataset that contains information on bilateral migration flows between the 15 main destination countries and approximately 200 origin countries between 1985 and 2004.

Data on PPP adjusted per worker GDP (constant 2000 international dollars) and population are from the Penn World Tables 6.2. Average years of schooling are taken from Barro & Lee (2000), the share of population aged between 15 and 29 years from the ILO Labour Force Statistics and measures of income inequality from the United Nations WIDER Institute. Data on the traditional gravity variables distance, common language and the existence of a colonial relationship are from CEPII's distance database[8].

Primary information on migrant stocks are from the Docquier & Marfouk (2005) database that reports migrant stocks for 30 destination countries and 192 origin countries for the years 1990 and 2000. In combination with the gross migration flows from the United Nations IMSC database, an interpolation procedure, similar to the one of Clark et al. (2007) allows us to obtain yearly migrant stocks for the years 1985-2004.

We estimate the elasticity of migration flows with respect to its main determinants using the following specification:

$$\begin{aligned} mig_{dot}/pop_{ot} &= \beta_0 + \beta_1(y_d/y_o)_{t-1} + \beta_2(syr_d/syr_o)_t + \beta_3 age_{ot} \\ &+\beta_4 ineq_{ot} + \beta_5(ineq_{ot})^2 + \beta_6 pov_{ot} + \beta_7 dist_{do} \\ &+\beta_8 comlang_{do} + \beta_9 colony_{do} + \beta_{10}(stock_{do,t-1}/pop_{d,t-1}) \\ &+\beta_{11}(stock_{do,t-1}/pop_{d,t-1})^2 + \kappa_{dt} + \kappa_t + \epsilon_{dot} \end{aligned} \quad (1)$$

where the d subscript denotes the destination country, o the origin and t the year. Following the literature (Mayda (2007) or Clark et al. (2007) among others) we choose the emigration rate, mig/pop, as the dependent variable of our empirical model.

Migration incentives are represented by the first five terms on the right-hand side of Equation (1). y_d/y_o is the (PPP adjusted) ratio of income per worker in the destination country relative to the origin country. This is our main variable of interest and we expect the estimated coefficient to be positive ($\beta_1 > 0$). syr_d/syr_o is the ratio of the average years of schooling in the destination country relative to the origin country. This variable adjusts the income per worker ratio for differences in human capital. For a given income per worker ratio, we expect the migration rate to be higher when human capital in the origin country is relatively higher relative to human capital in the destination country, since this would imply a relatively lower return to human capital in the origin country. We therefore expect the coefficient on the ratio between human capital in the destination country and in the origin country to be negative ($\beta_2 < 0$)[9]. age_{ot} is the share of the population aged between 15 and 29 years in the origin country and is supposed to capture the fact that, at a given level of the income per worker differential, the present value of migration is higher at younger ages. We therefore expect $\beta_3 > 0$. The variable $ineq_{ot}$ measures inequality in the origin country. Following Clark et al. (2007) and in line with the Roy model, we assume that the effect of inequality is nonlinear in the sense that increases in inequality have an upwards effect on the emigration rate at low levels of inequality but reduce it at high levels ($\beta_4 > 0$ and $\beta_5 < 0$).

Migration costs are represented by the remaining terms on the right-hand side of Equation (1). Poverty in the origin country, pov_{ot} can be considered as a constraint on emigration.[10] We therefore expect $\beta_6 < 0$. Geographical and cultural migration costs

[8]http://www.cepii.fr/francgraph/bdd/distances.htm

[9]The income and schooling ratios are positively correlated but this does not create a multicollinearity problem here, with the correlation coefficient between the two variables at around 0.66.

[10]Since there are no data on poverty headcount available for the countries and years in our sample,

are proxied by the traditional gravity variables distance, $dist_{do}$, common language, $comlang_{do}$, and the presence of a colonial link, $colony_{do}$ ($\beta_7 < 0$, $\beta_8 > 0$, $\beta_9 > 0$). We further expect migration costs to decrease with the presence of an origin country migration network in period $t-1$ in the destination country, $stock_{do,t-1}/pop_{ot}$. To capture potential decreasing returns to network externalities we impose a quadratic structure of the network variable and expect $\beta_{10} > 0$ and $\beta_{11} < 0$.

We use panel estimation techniques to estimate Equation (1). This allows us to control for heterogeneity between countries that is not captured by our explanatory variables. The destination country times year specific effect κ_{dt} captures all unobserved characteristics of the destination country in a specific year. In particular, the destination times year specific effect captures the restrictiveness of the destination's country's multilateral immigration policy toward all countries[11]. We do not include origin specific fixed effects since the reasons for including them are less apparent than for the destination country, where we want to control for unobserved migration policy[12]. The year specific effect κ_t captures time specific effects that are common to all destination and origin countries.

We report four sets of estimation results in Table 3. Column (1) reports results for estimation of specification (1) with destination country fixed effects instead of destination country times year fixed effects. All the coefficients have the expected sign and are statistically significant at the 10% level, except for the share of the young population in the origin country. In particular the coefficient on the income per worker differential is positive and statistically significant at the 5% level. The marginal effect of the income per worker differential on the emigration rate is estimated at 0.003 meaning that an increase of one percentage point of the GDP per worker ratio implies an increase of 0.003 percentage point of the emigration rate. Column (2) reports results for estimation of specification (1) with destination country plus year fixed effects to account for changes in immigration policy in the destination country. The results do not change qualitatively and the estimated marginal effect of the income per worker differential on the emigration rate remains roughly constant at 0.004. Columns (3) and (4) repeat the estimations using the origin migration network in the destination country in period $t-5$ instead of period $t-1$ to reduce potential endogeneity of the network variable. The coefficient on the share of the young population in the origin country now turns significant at the 1% level and has the expected sign while the other results remain qualitatively unchanged.

Among the factors that have been highlighted by the econometric analysis are some endogenous variables of the INGENUE2 model. Three are retained to endogenize migration flows[13]. The first two are related to economic factors and the third one

we follow Clark et al. (2007) and measure poverty by the inverse of income per capita squared.

[11]If a destination country differentiates between migrants from different origin countries, the destination times year specific effects only control for its overall migration policy stance and not for its bilateral stance with respect to a specific origin country.

[12]Note that this specification is equivalent to the Clark et al. (2007) specification in a setting with multiple destination countries and multiple origin countries.

[13]We thus assume that other determinants of emigration rates included in Equation 1 remain constant for the entire projection period. Even though this is naturally the case for some of them (distance, common language, colonial link), we are aware of the limitations of this partial integration of the migration determinants in our CGE framework. However, given the complexity of the task, we leave a more complete integration of migration determinants in such a world model to further research.

Table 3: Main determinants of international migration

	(1)	(2)	(3)	(4)
Dependent variable		Emigration rate		
gdp per cap diff	0.003**	0.004***	0.003*	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
human cap diff	-0.007***	-0.010***	-0.006**	-0.009***
	(0.003)	(0.003)	(0.003)	(0.003)
origin share young pop	0.001	0.002	0.003**	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
gini origin	0.005**	0.005**	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)
(gini origin)2	-0.000*	-0.000	-0.000**	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
origin pov	-0.002**	-0.002***	-0.002**	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
network	0.039***	0.041***	0.044***	0.046***
	(0.001)	(0.001)	(0.001)	(0.001)
(network)2	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
ln dist	-0.061***	-0.060***	-0.066***	-0.065***
	(0.005)	(0.005)	(0.005)	(0.005)
colonial link	0.046**	0.045**	0.064***	0.049**
	(0.018)	(0.018)	(0.021)	(0.021)
common language	0.110***	0.101***	0.132***	0.121***
	(0.010)	(0.010)	(0.012)	(0.012)
Destination FE	Yes	No	Yes	No
Destination-year FE	No	Yes	No	Yes
N	13295	13295	10274	10274
R2	0.52	0.55	0.51	0.55

Standard errors in parentheses
Significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors' calculations.

accounts for network effects: (i) the GDP per worker differential captures the fact that many workers move mainly for higher income opportunities ; (ii) the poverty indicator measures a constraint to the migration in the origin country ; (iii) an accumulated stock of immigrants in a specific country encourages migration in direction of this country for future years. The estimated marginal effects presented in Table 3 allow us to back out a range for the elasticity of the emigration rate with respect to each of the three retained factors. For example, using $\sigma \equiv \beta_1 \frac{(y_d/y_o)}{(mig/pop)_{do}}$, at the sample median for $\frac{(y_d/y_o)}{(mig/pop)_{do}}$, this elasticity would range from 0.43 to 0.57 for the per worker income differential. Given that a period is set to 5 years in the INGENUE 2 model, we choose specification 4 to endogenize migration flows and adopt an elasticity of 0.43 for the per worker income differential. The interpretation is that a 10% increase of the per worker income ratio involves a 4.3% increase of the emigration rate. Following the same methodology, we infer elasticities of the emigration rate with respect to the poverty indicator and with respect to the accumulated stock of immigrants, respectively equal to -0.03 and 0.43.

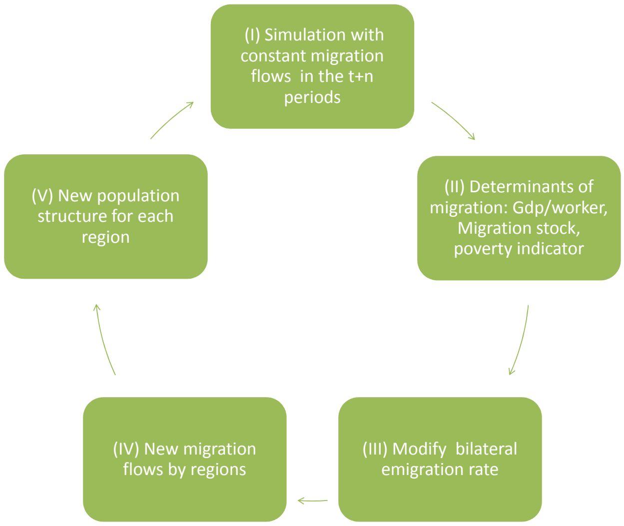
4.2 Evaluation of future migration flows

Some migration streams are durable, lasting decades, and relatively predictable such as labor migration or family reunification that tend to perpetuate themselves over time. Consequently, the migration flows that are strongest and most likely to endure are probably the flows toward the traditional countries of immigration. In this work, we only consider Western Europe and North America as the two only receiving regions that would be concerned by endogenous migration flows in the context of the Ingenue 2 model. Indeed, Eastern Europe and the Russian World, as potential receiving regions, are excluded from this endogenous migration process given that the recent period has been mainly marked by ethnic and conflict-driven migration that are by definition unpredictable.

The methodology to endogenize migration flows is relatively simple (Figure 3). The starting point for migration is still the year 2005 and the flows for the first period (2005-2009) thus remain the same as the one calibrated in the exogenous scenario. Then, the 14 bilateral emigration rates of the first period (2 destination regions and 7 origin regions) are modified on the basis of the endogenous evolution of the 3 determinants of international migration and of the 3 related elasticities. We then obtain 14 new bilateral emigration rates for the period 2010-2014, which allows us to calibrate new migration flows for this period. These new migration flows then modify the macroeconomic dynamics of the INGENUE2 model, for example the GDP per worker evolution, and create a dynamic feedback loop between migration projections and the demographic and macroeconomic evolutions.[14] This methodology is replicated for each period until 2050. After this date, migration flows progressively decline and are nil in 2150.

[14]Note that emigration rates are calibrated in a single step process at each period. Indeed, once emigration rates are fixed for a given year, endogenizing migration for future periods slightly modifies the dynamics of macroeconomic variables such as the GDP per worker differential given the perfect foresight assumption of the INGENUE2 model. However, these changes are very marginal compared to the first order effect on emigration rates and we thus choose not to include these second order effects so as to simplify the simulation process.

Figure 3: Endogenizing migration flows



The results of the endogenous migration scenario are presented in Table 4 where we compare exogenous migration flows of the United-Nations (2006) scenario (the one presented in Section 3.2) to endogenous migration flows for the period 2006-2050. Taking into account traditional economic and demographic determinants of migration flows (GDP per worker differential, poverty in origin countries and network effect) induces important changes in the volume and the distribution of the migration flows between regions compared to the United-Nations (2006) scenario. Indeed, some sending regions face substantial increase of their net migration flows by the middle of the century – for example, net migration flows from Africa and from the Mediterranean World are, respectively, almost four times and twice higher compared to the United-Nations (2006) projection– while other regions, such as the Chinese World are clearly less affected. As a consequence, we observe higher immigration in the receinving regions: the number of migrants in 2050 increases from 1.1 million to 1.9 million in North America (+63%); in Western Europe the number of migrants increase by 173%, reaching 1.5 million in 2050.

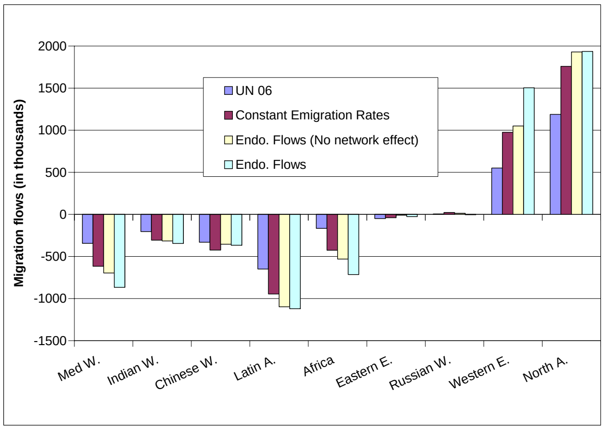
Table 4: Comparison of yearly net migration flows between the UN and the endogenous migration scenario (in thousand)

		2006-2010	**2011-2015**	**2016-2020**	**2026-2030**	**2046-2050**
Mediterranean World	UN 06	-397	-350	-341	-344	-344
	Endo. Flows	-397	-442	-491	-604	-867
Indian World	UN 06	-220	-205	-203	-204	-204
	Endo. Flows	-220	-237	-254	-287	-346
Chinese World	UN 06	-360	-333	-330	-331	-331
	Endo. Flows	-360	-368	-376	-382	-366
Latin America	UN 06	-701	-653	-648	-649	-649
	Endo. Flows	-701	-762	-816	-927	-1 120
Africa	UN 06	-195	-169	-165	-166	-166
	Endo. Flows	-195	-233	-278	-391	-715
Eastern Europe	UN 06	-50	-50	-50	-50	-50
	Endo. Flows	-50	-47	-44	-39	-26
Russian World	UN 06	3	5	5	5	5
	Endo. Flows	3	-1	-3	-4	-4
Western Europe	UN 06	654	564	546	551	551
	Endo. Flows	624	702	788	992	1 504
North America	UN 06	1 267	1 193	1 186	1 188	1 188
	Endo. Flows	1 297	1 390	1 474	1 643	1 936

Sources:United-Nations (2006), Authors' calculations

To clarify the mechanism behind these results, Figure 4 displays the number of migrants in 2050 for the different regions of the model according to several intermediate scenarios: we decompose between constant emigration rates[15], endogenous flows without network effects and complete endogenous flows. We see that switching from the United-Nations (2006) scenario to the constant emigration rate scenario induces an increase in migration flows in all regions. This result is logically linked to the total population evolution of each region. Africa, which is still characterized by high fertility rates through 2050, has still a growing population and is thus the most affected region by the constant emigration rates scenario.

Figure 4: Disentangling the demographic and economic effects of endogenous flows



sources: United-Nations (2006), authors' calculation

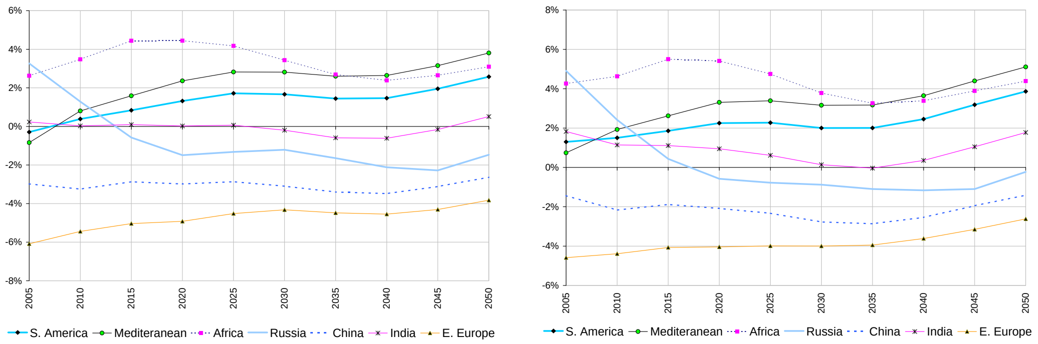
Introducing the economic determinants of migration, i.e. the GDP per worker differential and poverty in origin countries (endogenous scenario without network effects), induces additional flows from almost all sending regions (Figure 4). Indeed, the endogenous process of the INGENUE 2 model relies on two exogenous blocks : the catching-up process and the demographic forecasts for the ten regions of the model. Given the relatively conservative assumptions regarding the evolution of TFP (see Section 2) and demographic evolutions, only the Chinese World and Eastern Europe (and to a lower extent the Russian world) are catching up in term of GDP per worker to Western Europe and North America (Figure 5). However, one should note that the migration dynamics modify the catching-up process through the decrease in the GDP per worker differential between the receiving and sending regions (see figure 6(h)).

The comparison of the endogenous scenario without network effects with the complete endogenous scenario shows that migration flows are enhanced as we could expect (Figure 4). However, regarding receiving regions, one must note that the network effect does not add a lot of migrants for the North American region, contrary to the Western Europe region: with the introduction of the network effect, the number of migrants in 2050 is nearly the same in North America (+0.4%); in Western Europe the number of migrants increase by 43%. These differences on the number of migrants induced by the network effect could be explained by the fact that the

[15]The constant emigration rate scenario is strictly the same as assuming that there is no evolution of the 3 determinants of migration flows over time.

Figure 5: Growth rate of the GDP per worker differential in the endogenous flows scenario

(a) Compared to Western Europe (b) Compared to North America



source: authors' calculation

initial value of settled migrants is already high in 2000: the share of migrants is equal to 6.2% in Western Europe compared to 13.6% in North America, according to the United-Nations (Table 5). As a consequence, the estimated elasticity we use applies to a stock of migrants that is substantially higher in the North American case: new migration flows after 2000 thus have a moderate impact on the migrants stock evolution. In 2050, the respective shares of migrants are respectively equal to 14.5% and 17.6%.

Table 5: Share of international migrants in destination regions

		2000	2010	2020	2030	2040	2050
Western Europe	UN 06	6.2%	7.2%	7.9%	8.6%	9.1%	9.4%
	Endo. Flows	6.2%	7.3%	8.7%	10.4%	12.4%	14.5%
North America	UN 06	13.6%	14.9%	15.3%	15.5%	15.3%	14.7%
	Endo. Flows	13.6%	15.1%	16.1%	17.0%	17.5%	17.6%

Sources: Authors' calculations

5 Macroeconomic consequences of international migration

The results of the endogenous migration scenario are compared to the benchmark with no migration (see Figure 6). The introduction of international migration in our demographic model strongly modifies the international distribution and the age structure of the world population for the concerned regions. Thus, North America and Western Europe have a total population respectively 43.5% and 30.2% higher than in the baseline case in 2050. At the same time, the population of Latin America, Mediterranean world, Eastern Europe and Africa is respectively 11.7%, 9.7% 2.8% and 2.9% lower. Other emigration regions are less affected by migration flows.

International migration flows also modify the age structure of the world population since migrants are assumed to be young workers (aged 20-24). In 2050, the dependency ratio (defined as the non-working population aged more than 60 in percentage of the total effective working-age population) is almost 26.5 points lower than in the baseline case in Western Europe (Figure 6(b)) and 17.2 points in North America. At this horizon, it increases by about 5.2 points in Latin America, 3.1 points in Mediterranean World and 2.6 points in Eastern Europe [16]. It follows that the financing of the PAYG pension system is substantially improved (resp. deteriorated) in North America and Western Europe (resp. in sending regions) in line with the dependency ratio evolution (Table 6). For instance, in the European case, the contribution rate is 6.4 percentage points lower in the endogenous flows scenario in 2050 compared to the baseline without migration (2.5 percentage points lower than the UN scenario). Given that the contribution rate is likely to increase by 14.8 percentage points between 2000 and 2050 in Western Europe, introducing endogenous migration flows reduces the financial burden arising from ageing by less than a half. Consequently, even if it induces a sharp increase in migration flows, this scenario does not totally offset the effect of ageing and thus raises the question of pension reforms in a near future.

Table 6: Contribution rates evolution

		2000	2010	2020	2030	2040	2050
Western Europe	Baseline	17.1%	19.1%	22.5%	27.6%	30.7%	31.9%
	UN 06	17.1%	18.7%	21.5%	25.4%	27.1%	28.0%
	Endo. Flows	17.1%	18.7%	21.3%	24.8%	25.7%	25.5%
North America	Baseline	9.1%	10.4%	13.4%	16.5%	17.4%	17.9%
	UN 06	9.1%	9.9%	12.1%	13.9%	13.7%	14.3%
	Endo. Flows	9.1%	9.8%	12.0%	13.6%	13.1%	13.4%

Sources: Authors' calculations

The impact of international migration flows on the GDP growth rate is far from being insignificant. The arrival of young workers progressively increases the GDP growth rate in North America and Western Europe. It is more than one percentage point higher than in the baseline case in 2050 in North America and Western Europe and then slightly diminishes with the ageing of first migrant cohorts (see Figure 6(f)). The mirror effect of the improving economic situation in immigration regions is a deterioration in the regions of emigration, and noticeably in Latin America and the Mediterranean world. Indeed, the magnitude of the deterioration depends on the loss of potential workers relative to the total labor force in the regions.

Nevertheless, the level of consumption per capita is less than in the baseline scenario in Western Europe until the beginning of the second half of the century (see Figure 6(g)). The reason is the production sector : the inflow of workers reduces capital intensity relative to baseline. Indeed, immigration can be seen as a supply shock on the labor market, thus impacting on the productivity of factors supplied by natives. For a given stock of capital, an increase in labor supply reduces the capital by worker. The marginal productivity of capital is raised and the interest rate as well.

[16]Note that the emigration rate in Eastern Europe is three times lower than in the Mediterranean world. Nevertheless, the negative impact on the dependency ratio is relatively similar and is explained by the different demographic features between these two regions. The former is much advanced in the ageing process whereas the latter is still characterized by a more sustained growth of its working age population. The consequences of young workers emigration are thus more pronounced in the Eastern Europe case.

Conversely, labor productivity falls with a lower capital intensity. As a consequence, GDP per worker is decreases in the regions receiving the migrants, which is mirrored in increases in the regions sending the migrants (see Figure 6(h)). These migration flows from regions with low levels of TFP to regions with higher levels of TFP thus induce a convergence process in terms of the GDP per worker differential.

The real wage rate, being a decreasing function of the return to capital on the factor price frontier, is itself on a lower path than in the baseline in receiving regions. It follows that relative to the baseline scenario, consumption is increased by less than total population ; hence consumption per capita is lower. Around 2035, when savings gain momentum (see Figure 6(c)) the interest rate recedes a bit because savings grow faster than investment. Therefore the growth of consumption per capita relative to baseline turns positive from 2025 onwards and the level exceeds the baseline in 2060. In North America, the level of consumption per capita is always lower than in the baseline given the net savings profile.

The opposite occurs in emigration regions. But the impact is diffused over several regions and mitigated by the size of the labor force. The fall in the interest rate in these regions and the subsequent increase in productivity persists for almost the entire span of the fifty year period. Only Latin America and the Mediterranean world exhibit a non-negligible elevation of consumption per capita.

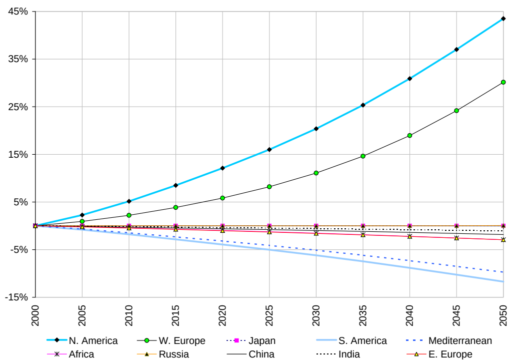
Savings increase in the regions receiving the migrants and gradually reach high deviations from the baseline scenario (see Figure 6(c)). This comes from the fact that the stock of first generation migrants enters progressively the high saving stage of their life cycle. In the regions sending the migrants, one must note an increase of savings. Two effects have to be taken into consideration. On the one hand, from a demographic point of view, savings should decrease as a consequence of the fall of the working age population. On the other hand, households have a strong incentive to increase their savings as the world interest rate is substantially higher than in the baseline scenario. This latter adjustment dominates and reflects the adjustment one must observe in this specific world setting framework. Indeed, in the INGENUE 2 model, the world interest rate balances at each period the capital supply and the capital demand at a world level. In this case, the higher interest rate reflects noticeably the strong increase in investment (capital demand) in the two regions receiving the migrants.[17]

The saving-investment balance is affected by the migration flows. In particular, in the regions receiving the migrants, saving and investment increase simultaneously (as explained above). The current account balance is more in surplus in the Western Europe region compared to the baseline case. In North America, the current account switches from a deficit in the baseline to a surplus during the period 2010-2015. It follows from the improvement of the current account balance that North America and Western Europe reinforce their creditor position in the world economy during the period 2015-2050. The ownership ratio rises systematically above baseline (see Figure 6(e)).

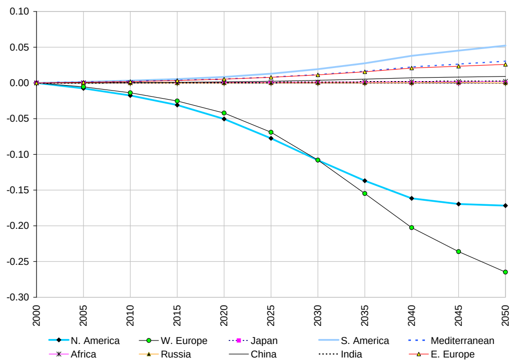
[17] In the hypothetical case of a unique receiving region (for example Western Europe), the increase of the world interest rate would be substantially lower and savings would then decrease in the regions sending the migrants. This specific simulation is not presented in the paper but is available upon request from the authors.

Figure 6: Results of the endogenous migration scenario (difference from baseline scenario): 2000-2050

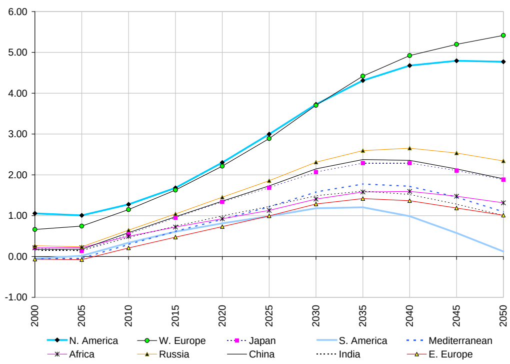
(a) Total population



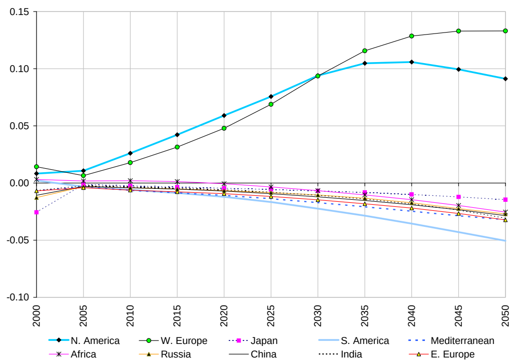
(b) Dependency ratio



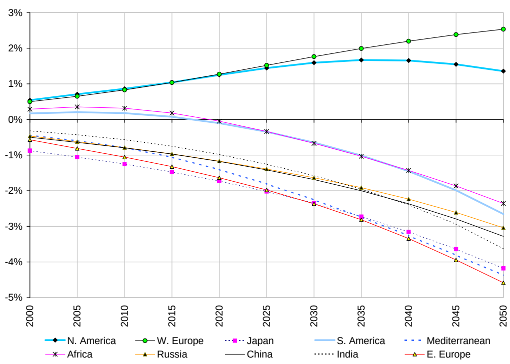
(c) Net Saving in % of GNP



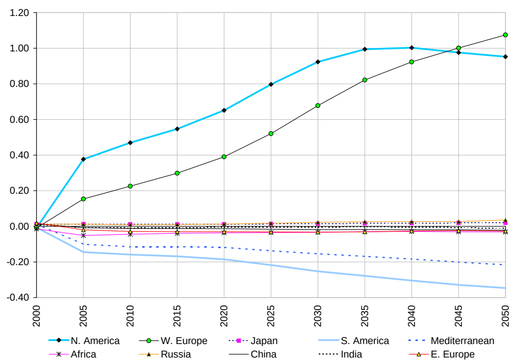
(d) Regional annual real interest rate



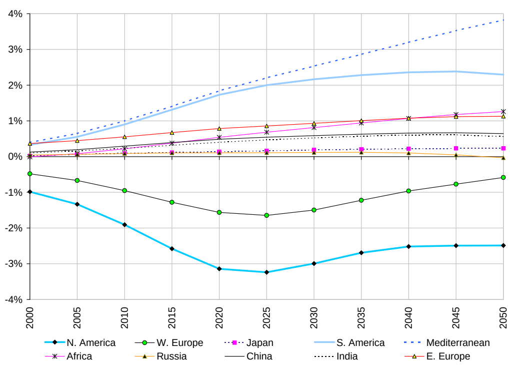
(e) Ownership Ratio



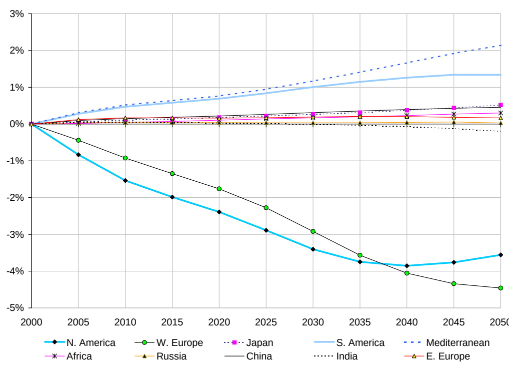
(f) GDP Growth rate



(g) Private consumption per capita (level)



(h) GDP per worker (level)



source: authors' calculation

6 Sensitivity analysis

6.1 Sensitivity to the perfect assimilation assumption

Several studies, such as Storesletten (2000), Chojnicki et al. (2005) and Fehr et al. (2003, 2004), demonstrate that immigration of high-skilled workers could be much more beneficial from the perspective of receiving countries than attracting low-skilled workers, particularly in the context of ageing. At the same time, the increase in the number of highly educated immigrants in the 1990s raises many questions related to the consequences of brain drain in developing countries. This question of skill heterogeneity is thus crucial when studying the consequences of international migration. In our model, immigrants are assumed to have exactly the same productivity as native workers. However, the skill composition of immigrants from developing regions suggests that they may be less skilled than the average European and North American worker. The perfect assimilation of migrants in terms of productivity implies thus an upper-bound estimate for output.

Introducing skill heterogeneity in our analytical framework would be a daunting task that would complicate the computation of the transition path, particularly with endogenous migration flows. However, it seems necessary to have some assessment of the quantitative effects of this assumption. To test the robustness of our results, we perform a similar analysis in which we test the opposite extreme assumption concerning economic assimilation: we assume in this variant that international migrants keep the productivity level of their origin country. From a technical point of view, we compute the aggregate productivity level for one region as a weighted average between the productivity of the natives and the productivity level of the migrants. The weight is changing at each period as the structure of the total labor force is affected by continuous migration flows[18]. As a result, the productivity levels of host regions are negatively affected (since migrants are less skilled on average) by migration from other regions. At the same time, the productivity level of origin countries remains the same.

In order to understand the consequences of such an assumption, we retain exactly the same flows as the ones simulated in the endogenous flows scenario. Simulations are therefore different only regarding the assumption of assimilation of productivity by migrants. Figure 7 presents some results on the GDP growth and GDP per worker evolution according to the retained assumption concerning economic assimilation. In particular, the pessimistic assumption of no assimilation progressively reduces the GDP growth rate in the two destination regions, compared to the endogenous flows scenario previously presented, following the decrease in the average productivity level of these two regions. For example, in 2050, the GDP growth rate would be around 0.2 percentage point lower in the two receiving countries if migrants keep the productivity level of sending regions (sending economies are only marginally affected by general equilibrium feedback effects). All things being equal, this assumption logically translates into a sharp decrease of host country GDP per worker. In 2050 it is reduced by almost 10% in the two regions (compared to values close to 4% in the perfect assimilation case). This "cumulative" effect comes from the fact that

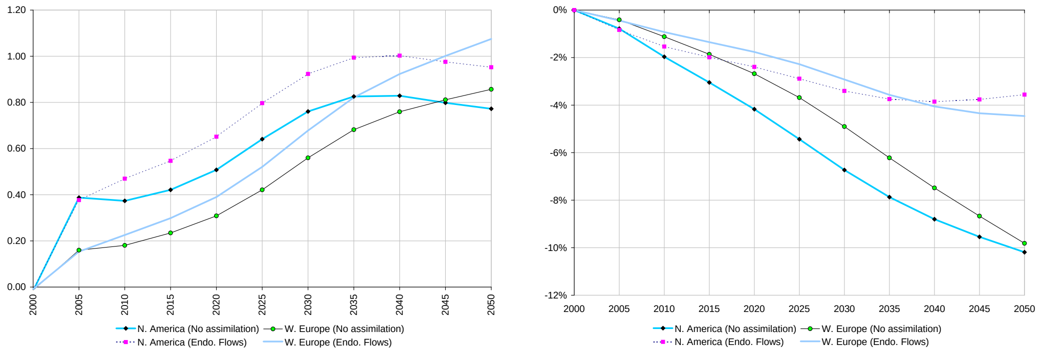
[18] Precisely, we use the migration stocks by origin regions in Western Europe and North America as well as the productivity level in sending regions to weight the productivity level in host regions.

the stock of less skilled workers entering the labor force of the destination regions is increasing during the period.

Figure 7: Impact of the perfect assimilation assumption (difference from baseline scenario): 2000-2050

(a) GDP Growth rate

(b) GDP per worker (level)



source: authors' calculation

Thus, results on the GDP per worker are clearly affected by the level of economic assimilation. Consequently, the GDP per capita differential between receiving and sending regions will be modified in the case with no assimilation. However, as highlighted in Figure 4, the GDP per capita differential seems to play only a marginal role in explaining migration projections. As a consequence, when computing endogenous migration flows (as in section 4.2) with the assumption of no assimilation, results appear close whatever the retained assumption on economic assimilation (see Table 7).

Table 7: Sensitivity of net migration flows to economic assimilation and TFP assumptions (difference from baseline scenario)

		2006-2010	2011-2015	2016-2020	2026-2030	2046-2050
Mediterranean World	No assimilation	0.0%	-0.7%	-0.2%	-1.0%	-2.4%
	High TFP	0.0%	-0.1%	-0.3%	-0.9%	-2.6%
Indian World	No assimilation	0.0%	-0.3%	-0.4%	-1.5%	-3.2%
	High TFP	0.0%	-0.3%	-0.6%	-1.4%	-3.3%
Chinese World	No assimilation	0.0%	-0.5%	-0.7%	-2.2%	-4.9%
	High TFP	0.0%	-0.5%	-1.0%	-2.3%	-5.1%
Latin America	No assimilation	0.0%	-1.2%	-0.7%	-2.4%	-5.0%
	High TFP	0.0%	-0.5%	-1.1%	-2.4%	-5.2%
Africa	No assimilation	0.0%	-0.3%	-0.3%	-1.1%	-2.7%
	High TFP	0.0%	-0.2%	-0.5%	-1.1%	-2.8%
Eastern Europe	No assimilation	0.0%	-0.5%	-0.4%	-1.9%	-4.8%
	High TFP	0.0%	-0.2%	-0.6%	-1.6%	-5.0%
Russian World	No assimilation	0.0%	-18.4%	-13.8%	-25.6%	-25.6%
	High TFP	0.0%	-28.1%	-20.1%	-30.5%	-30.5%
Western Europe	No assimilation	0.0%	-0.4%	-0.1%	-0.5%	-1.5%
	High TFP	0.0%	0.0%	-0.1%	-0.4%	-1.7%
North America	No assimilation	0.0%	-0.9%	-0.8%	-2.6%	-5.4%
	High TFP	0.0%	-0.6%	-1.2%	-2.6%	-5.6%

Result concerning Russian World is due to a scale effect, i.e. to very few migrants
Sources:United-Nations (2006), Authors' calculations

6.2 Sensitivity to the technological catching-up assumptions

The process of technological diffusion, which is the engine ofcatch-up, is based upon an assumption of convergence in total factor productivity described in section 2.

Since it contributes to define income, TFP is crucial to motivate migration choices. We thus analyze the consequences of an alternative assumption concerning TFP. We assume an increase by 10% compared to the baseline in the average annual growth rate of TFP between 2005 and 2100 (Table 8) in region where emigration takes place. TFP growth rates in Western Europe and North America (and Japan) remain the same.

Table 8: Total factor productivity average annual growth rate (2005-2100)

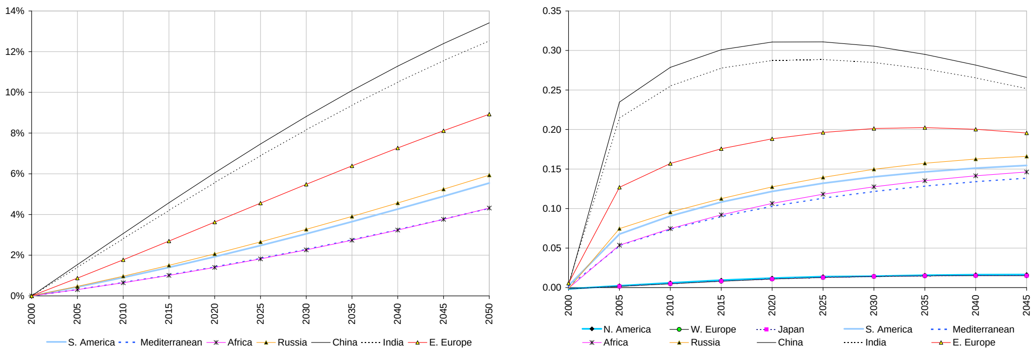
	L. Am.	Med.	Africa	Russia	China	India	E. Eur
Baseline	1.17%	1.12%	1.12%	1.24%	1.75%	1.70%	1.29%
High TFP	1.29%	1.23%	1.23%	1.37%	1.92%	1.87%	1.42%

Source: Authors calculations

The growth impact of the speed-up in technological diffusion is straightforward. In the regions that experience the upward shift of the production frontier, people rationally expect a higher trend of future real income. The improvement in consumption per capita is stronger in regions where the rise in TFP is larger (Figure 8). The higher trend in consumer demand boosts capital accumulation. The subsequent higher capital intensity gives a further upward twist to the productivity of labor. The result is a sharp acceleration in GDP growth to reach the new equilibrium in capital intensity. Then the growth profile in GDP per worker follows the one in TFP.

Figure 8: Impact of a higher TFP (difference from baseline scenario): 2000-2050

(a) Total Factor Productivity (level) (b) GDP growth - No migration



source: authors' calculation

Using higher profile of TFP for emigration regions thus reduces the gap in term of GDP per worker between sending and receiving regions. However, even if it reduces our endogenous migration flows (Table 7), the magnitude of endogenous migration flows remains the same whatever the retained assumption on TFP. For example, a 10% increase of average TFP reduces migration flows respectively by 5.2% and 2.8% in Latin America and Africa. Indeed, as previously demonstrated, migration flows are determined in great part by demographic determinants.

7 Conclusion

History teaches how the search of better living conditions and higher wages is a strong motive for emigration. From an economic perspective, migration flows around the world can be seen as a change in the geographic distribution of the global labor force. In the destination countries, the increase of the labor force, as long as most of the newcomers work, entails an increase in the return to capital which attracts capital flows. Of course, the reverse effect characterizes the sending countries. As a consequence, migration flows change the geographic structure of factor prices around the world. From this perspective, using a world general equilibrium model as INGENUE 2 in evaluating the migration flows for the next century has two main advantages. First, it allows studying simultaneously the impact of migration flows on the destination countries as well as on the sending countries. Second, it allows evaluating the feedback effect of capital flows and wage changes on migration flows.

The introduction of endogenous migration flows into INGENUE 2 sheds light on several important demographic and economic questions. First, migration could have a substantial impact on GDP growth in the regions receiving the migrants (positive impact) but also on the regions sending the migrants (negative impact). According to our simulations, Western Europe and North America should benefit substantially from the arrival of cohorts of migrants in the next decades. Second, despite their size, these flows will not be sufficient to counteract the impact of population ageing in these regions: even when immigration flows are taken into account, pension reforms in these ageing regions will remain necessary. In order to quantify this result, we can note that taking endogenous migration flows into account leads to a decrease of 6.5 percentage points of the contribution rate in Western Europe in 2050 (4.5 percentage points in North America), compared to the baseline scenario without migration.

With the interaction that we have modeled between the demographic part and the economic part of the world OLG model, we have been able to project dynamic migration flows. Note that this corresponds to one of the research priorities defined by the National Research Council (2000) in order to improve the projections of international migration flows. In our view, this work constitutes a first step in this direction and future research on projections of international migration flows could build on this methodology. Future work could develop our methodology further in several respects. Firstly, we do not analyze the differences between the impact of high-skilled and low-skilled immigrants. Secondly, remittances (associated with migration flows) are not modeled in our framework. Clearly, these flows could be of great importance, from a quantitative point of view. Thirdly, the INGENUE 2 model assumes perfect flexibility in the labor and goods markets. Thus, immigration has no impact on unemployment and economic output is continuously at potential. Finally, the age of migrants is limited to a specific age cohort and we do not model return migration. The limitations of our approach and the scope for further research notwithstanding, we consider it an important first step in analyzing international migration in a world general equilibrium model.

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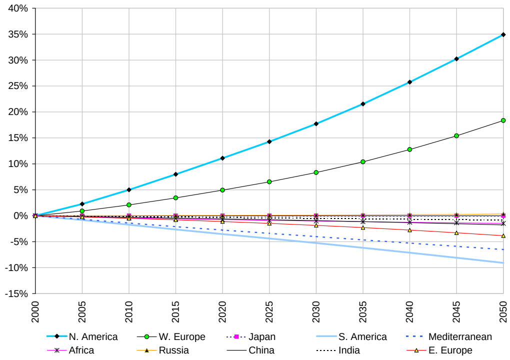
Appendix 1: Macroeconomic consequences of the conventional (UN06) migration scenario

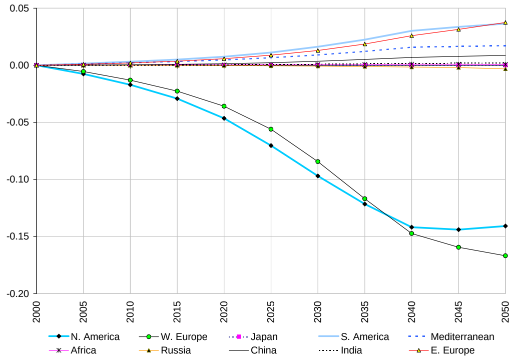
In this appendix, we present the results of the exogenous migration scenario based on United-Nations (2006) projections presented in section 3.2.

Figure 9: Results of the UN migration scenario (difference from baseline scenario): 2000-2050

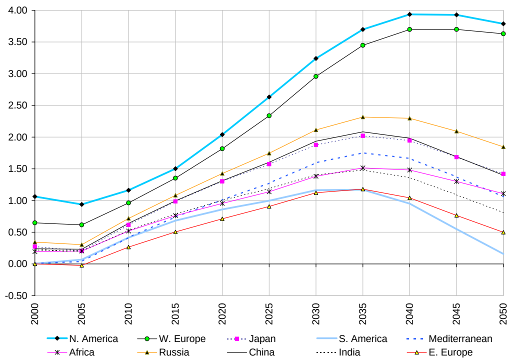
(a) Total population



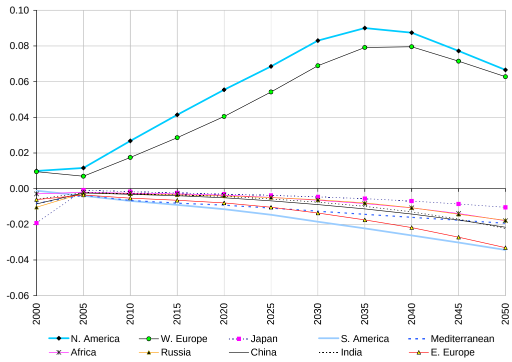
(b) Dependency ratio



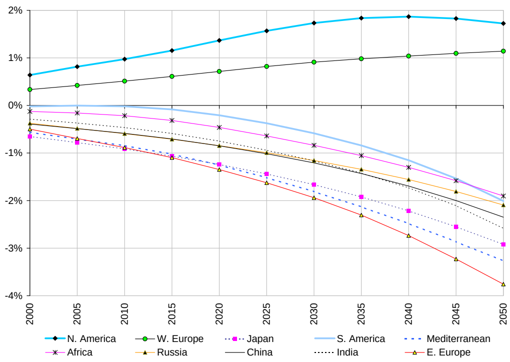
(c) Net Saving in % of GNP



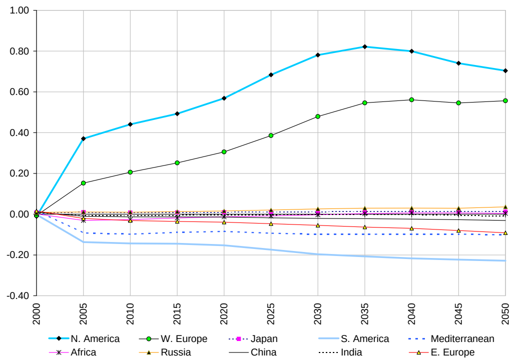
(d) Regional annual real interest rate



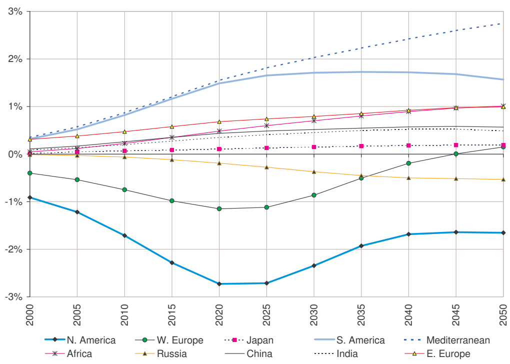
(e) Ownership Ratio



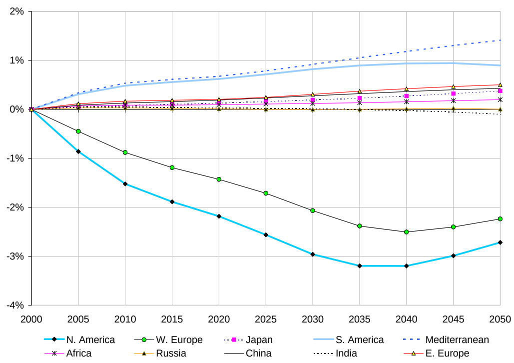
(f) GDP Growth rate



(g) Private consumption per capita (level)



(h) GDP per worker (level)



source: authors' calculation

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